All Seasons Cavity Analysis Results

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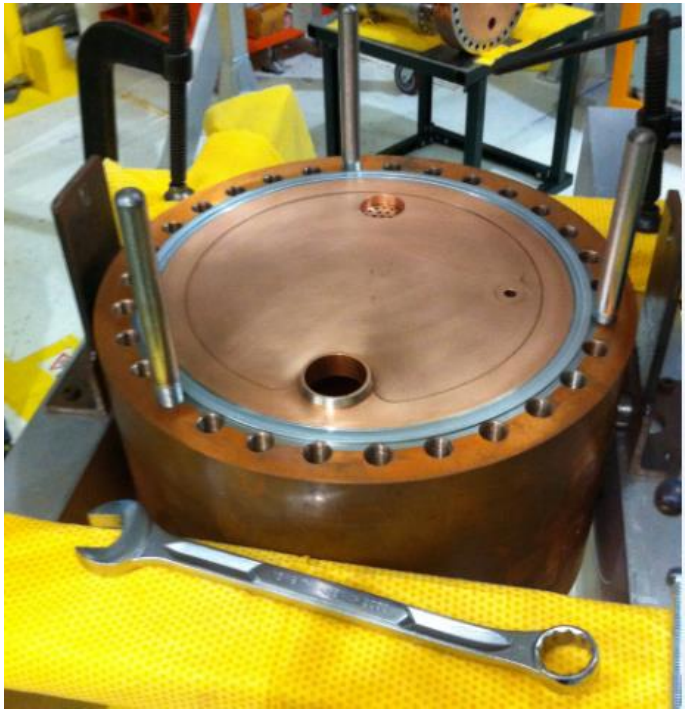
Talk structure

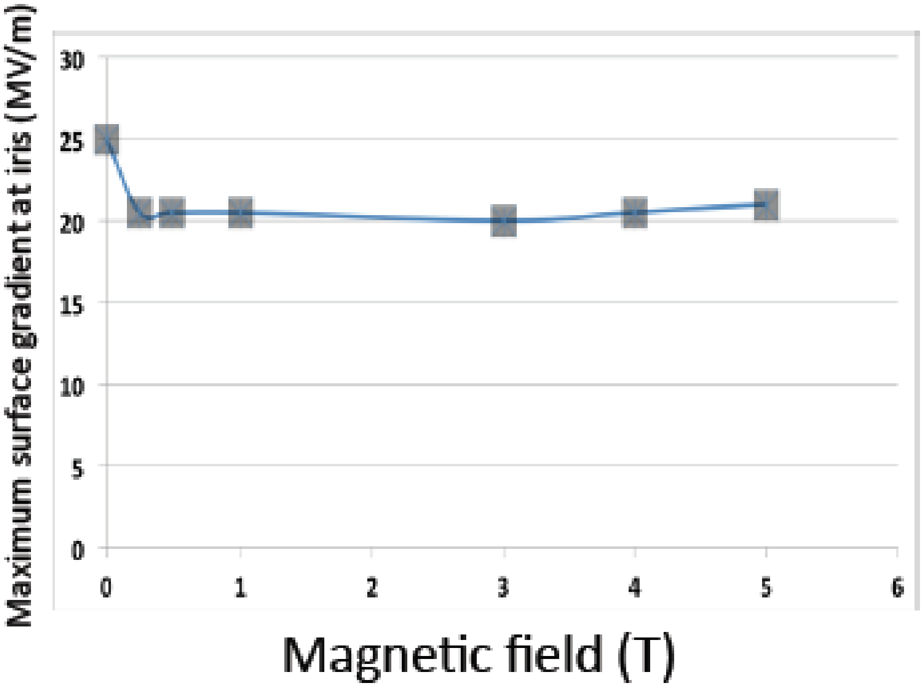
- All Seasons Cavity (ASC)
- Breakdown physics
- Dark current simulations and calculations
- Results
- Conclusion

All Seasons Cavity (ASC)

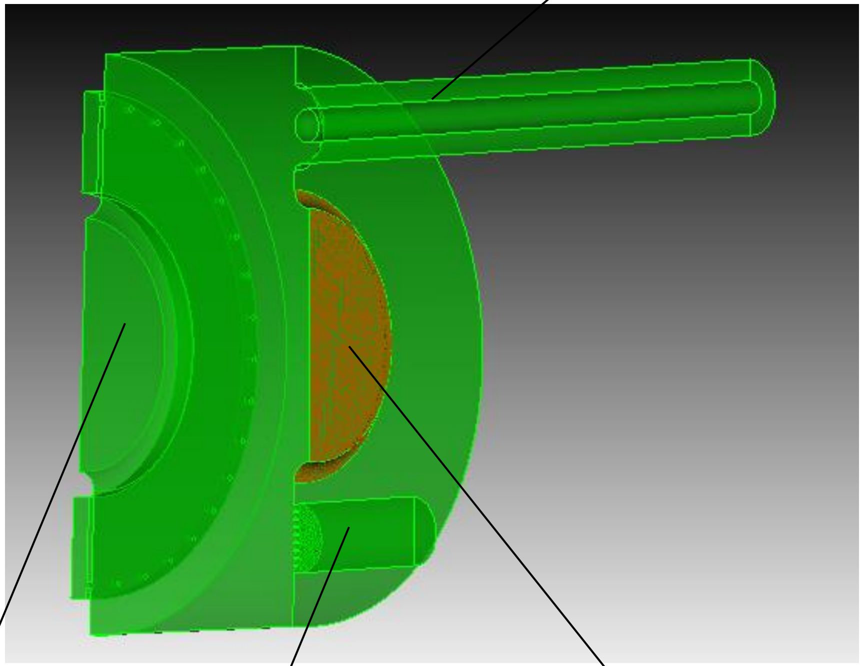
Was designed to be operated under various conditions

Can the data provide us more info about BD?





ASC Geometry

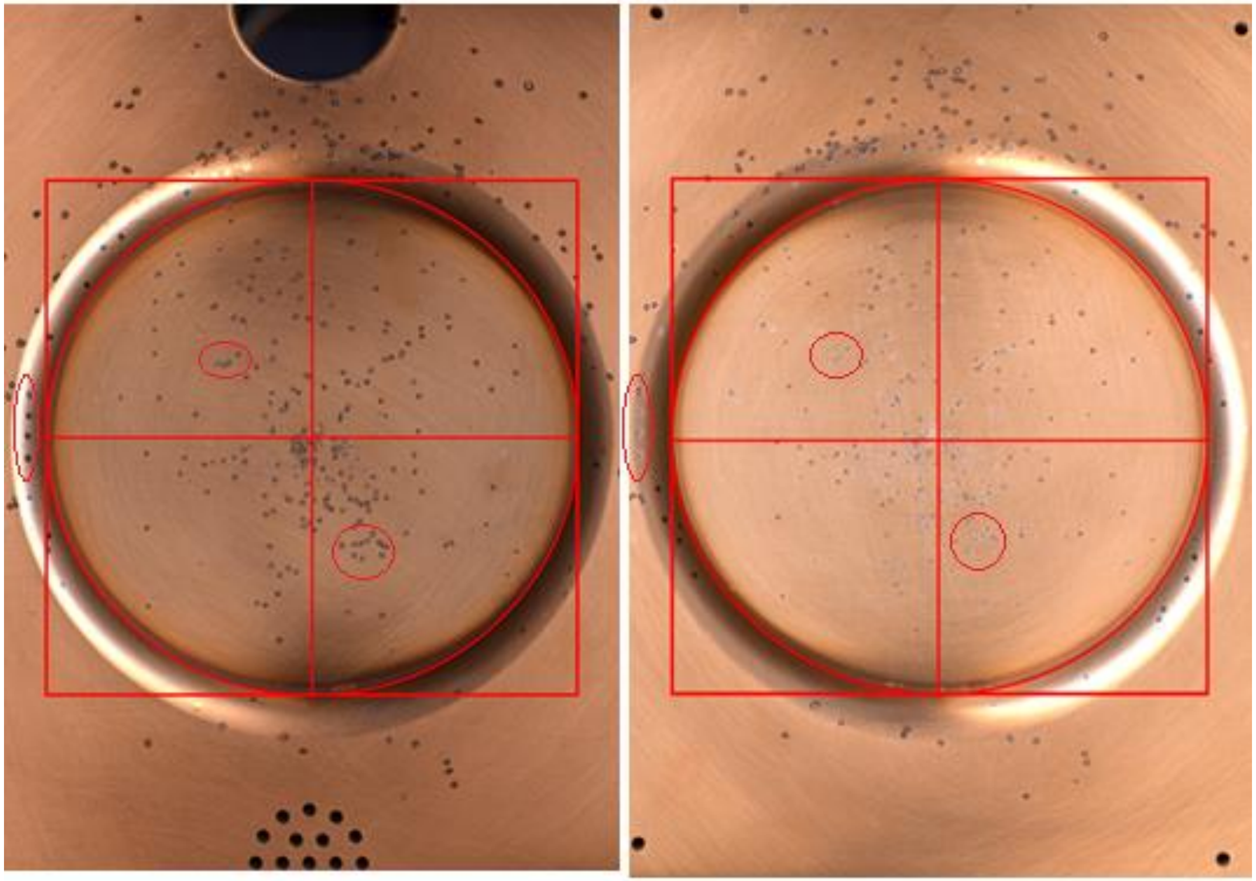


Frequency = 810MHz

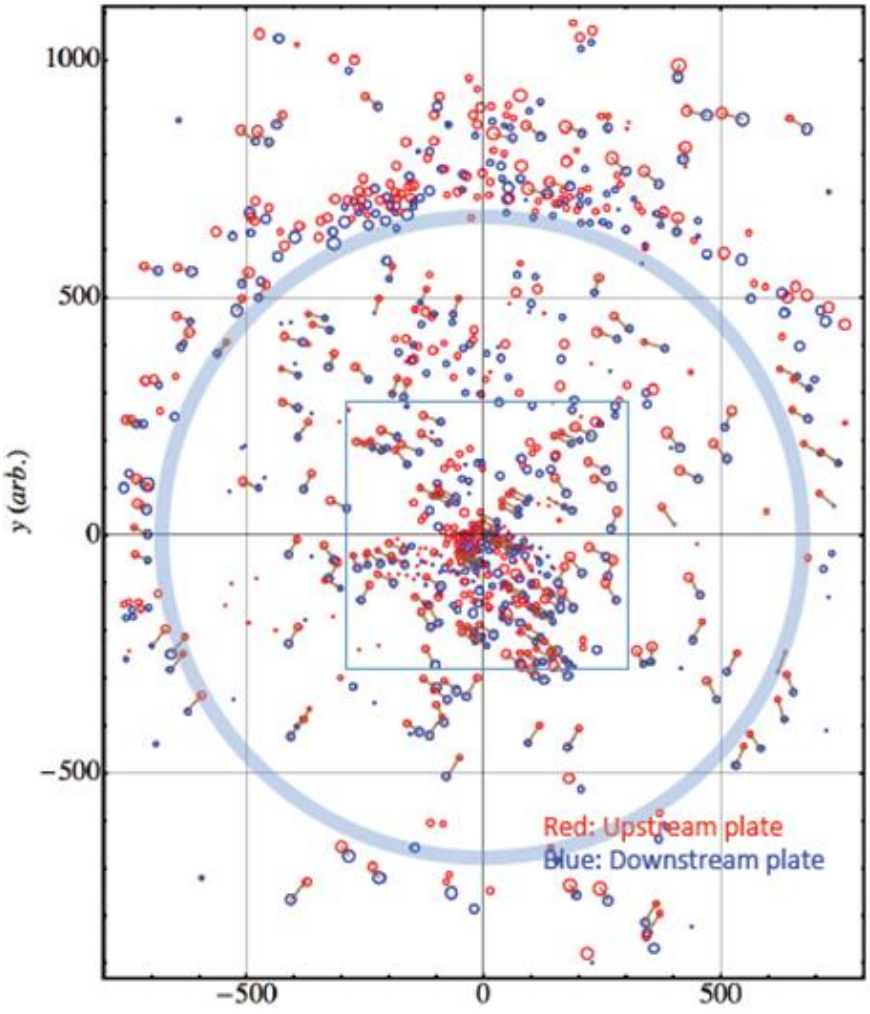
Gap length = 15cm

Radius = 14.5cm

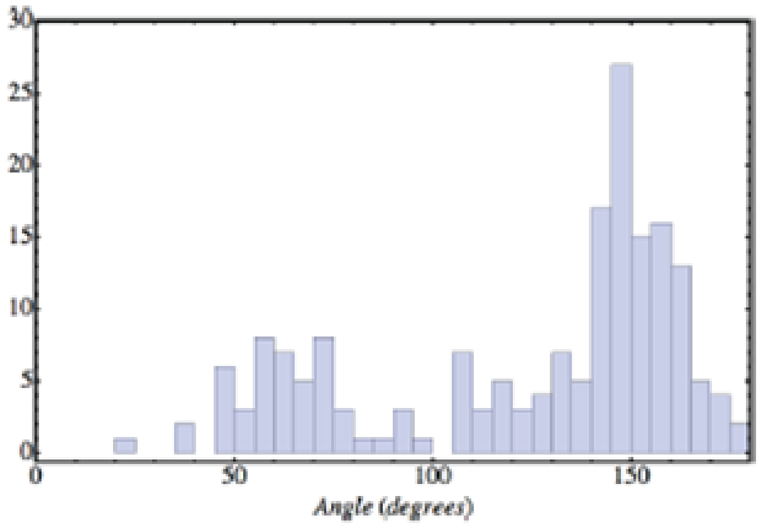
Breakdown pits



Breakdown pits distribution

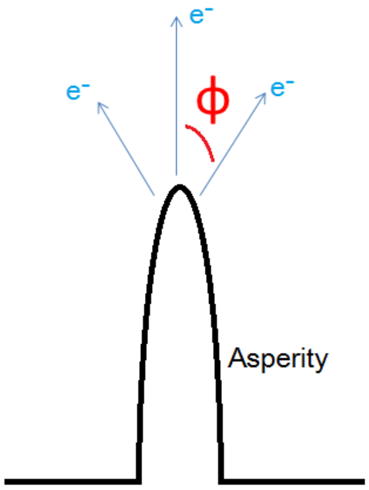


Histogram of pit orientations



Can we explain that distribution? Can we deduce something from the pattern?

Fowler-Nordheim emission model



Describes electron emission from metal surface

Surface field enhancement factor can be up to several hundreds

Work function

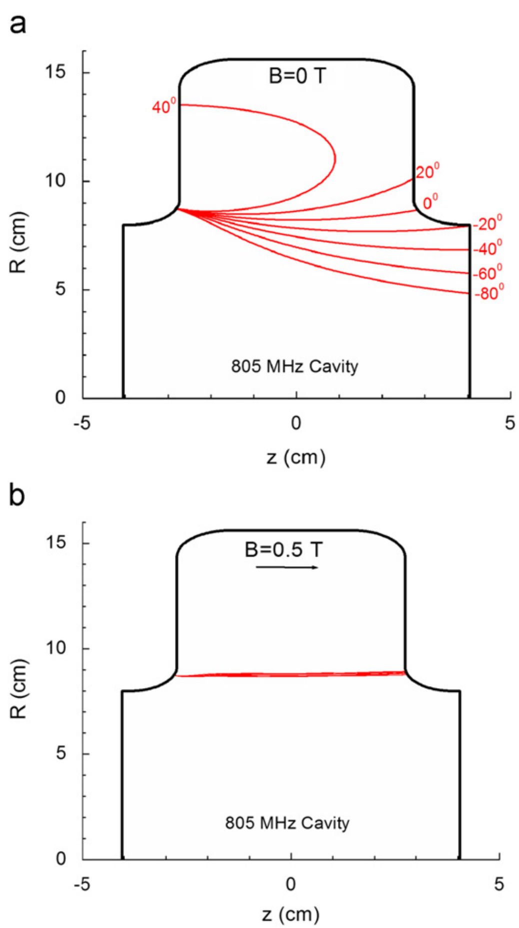
Fowler-Noldheim formula

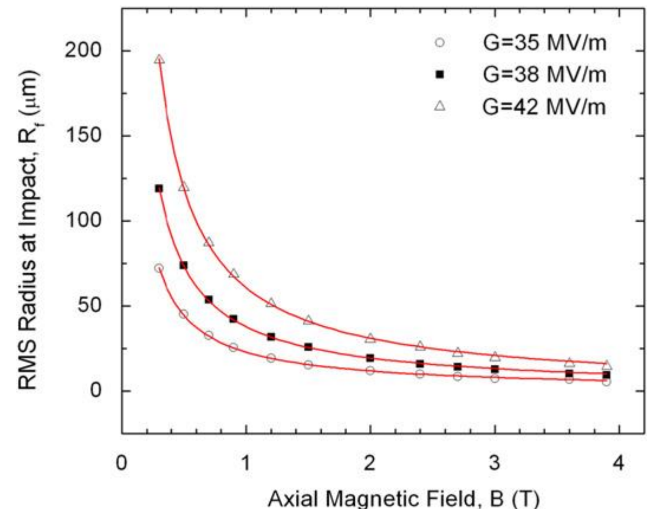
$$i(\beta E) = \frac{A_{fn}(\beta E)^2}{\phi} Exp\left[-\frac{B_{fn}\phi^{3/2}}{\beta E}\right]$$

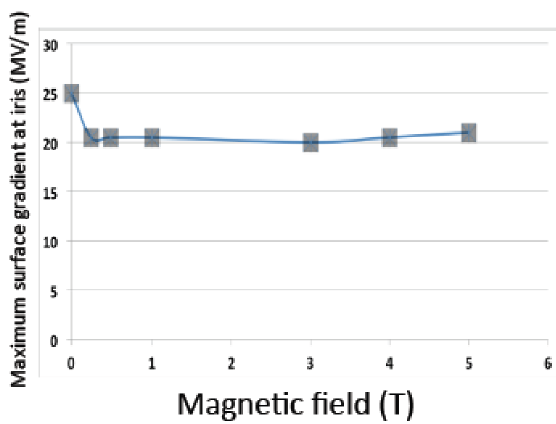
A_{fn} = 1.54e6 eV A MV^{-2}
B_{fn} = 6830 MV m^{-1} eV$^{-3/2}$
Work function = 5 eV

Can be used to calculate the energy of electron beam

Magnetic field effect on breakdown







[Effects of external magnetic fields on the operation of high-gradient accelerating structures. Diktys Stratakis , JuanC.Gallardo, Robert B.Palmer]

Electron motion inside the cavity

$$\frac{d\boldsymbol{p}}{dt} = q(\mathbf{E}+\boldsymbol{v}\times\mathbf{B}) = q\begin{pmatrix} 0 \\ 0 \\ E_z(t) \end{pmatrix} + q\begin{pmatrix} i & j & k \\ v_x & v_y & v_z \\ B_x & B_y & B_z \end{pmatrix}$$

Longitudinal motion

$$\frac{m\ddot{z}}{(1-(\frac{\dot{z}}{c})^2)^{\frac{3}{2}}} = qE_o sin(2\pi f+\phi)+(\dot{x}B_y-\dot{y}B_x)$$

Relativistic correction

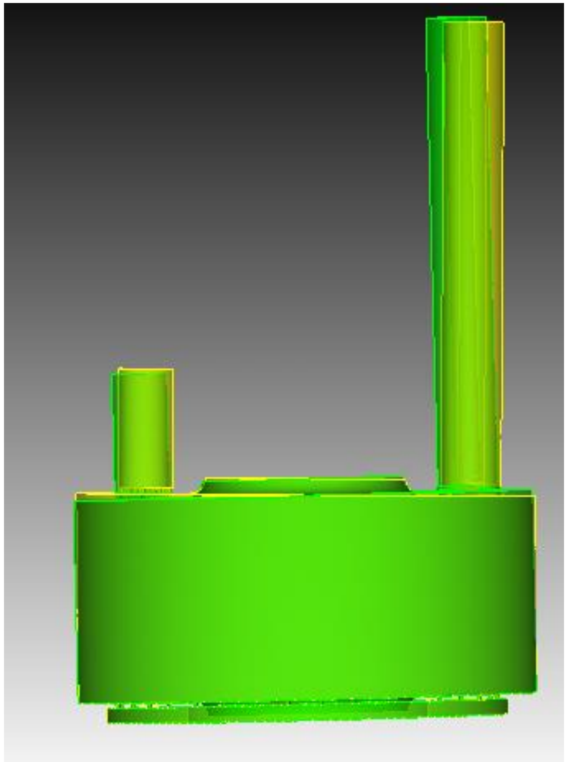
B_x, B_y consist of:

- External B field
- B_θ RF component
- B_r component from magnet

Simulation: model parameters

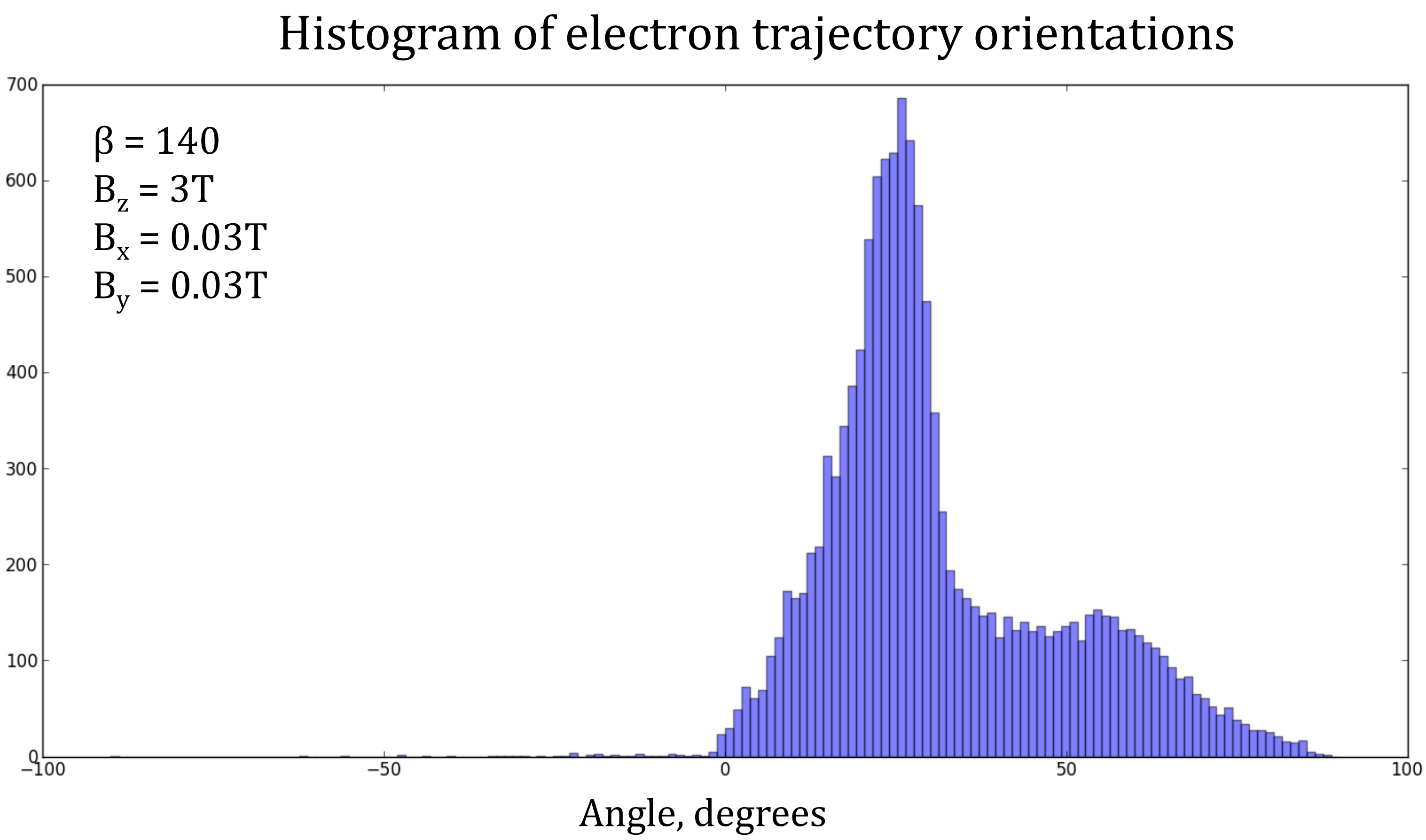
- ACE3P simulation package
- B_z = 3 Tesla
- Field enhancement factor range [140, 180]
- Constant 20MV/m field gradient
- Electron trajectories between upstream and downstream end plate
- Introducing "cavity misalignment" B_x, $B_y > 0$
- Checking both tilted and not-tilted scenarios

Tilted upstream endplate



Angle of tilt $\sim 1.5^o$

Simulation results: example

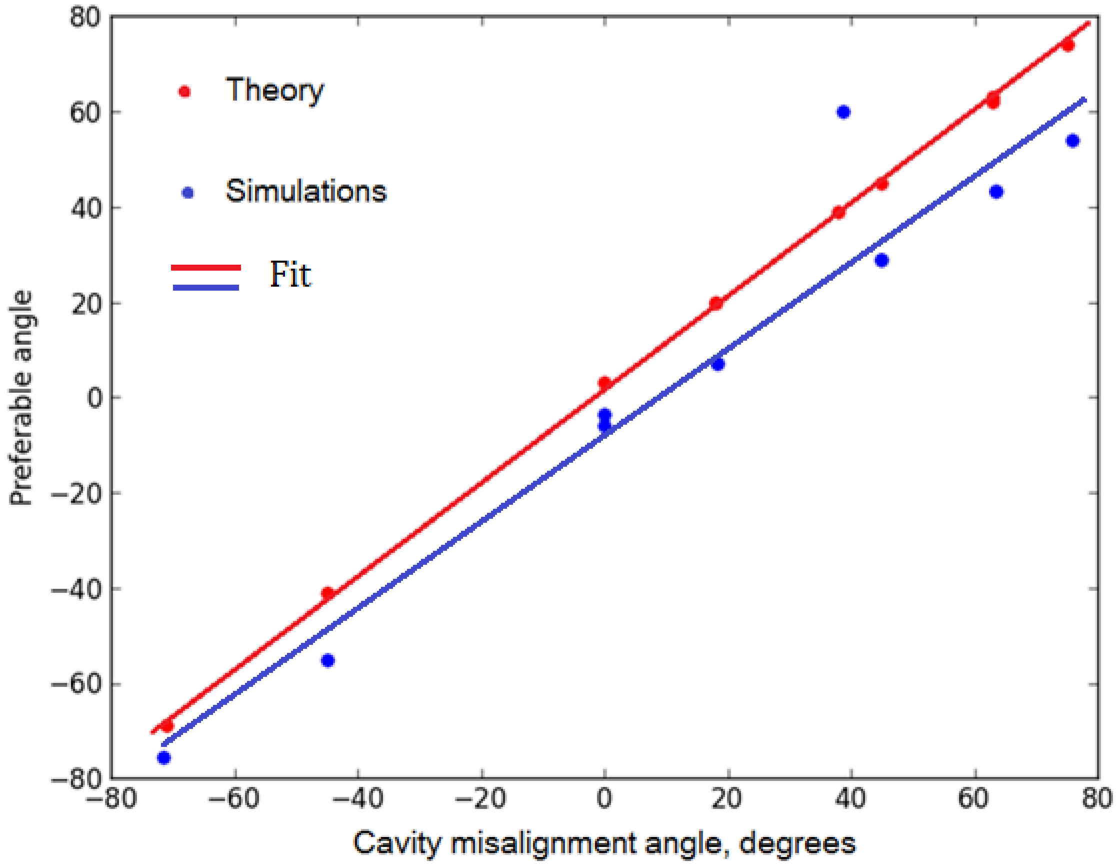


Calculation model

- System of differential equations for electron motion inside the cavity
- RF fields are approximated by pillbox field solutions
- Complex E(z) dependence is taken into account
- External magnetic fields: $B_z = 3T$, B_x, B_y misalignment
- Field map from MTA magnet

Results

Preferable angle correlation with misalignment



Conclusion

- Analysis is on-going
- Model calculating trajectory of a single electron is implemented
- Dark current simulation analysis procedure is developed
- Results confirm the hypothesis that cavity misalignment in external magnetic field might cause certain pit orientation
- Has a potential to be diagnostics technique
- The tools developed for ASC effort is relevant for future Modular Cavity data analysis of breakdown damage data.

- Submitted abstract for IPAC’15